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FIRST DESCRIPTION AND SURVEY OF THE EGG MASSES OF *LOLIGO GAHI* (D'ORBIGNY, 1835) AND *LOLIGO SANPAULENSIS* (BRAKONIECKI, 1984) FROM COASTAL WATERS OF PATAGONIA

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ABSTRACT A survey was conducted on the egg masses of *Loligo gahi* (D'Orbigny, 1835), a target of an important squid fishery in the Southwest Atlantic, and *L. sanpaulensis* (Brakoniecki, 1984), a species exploited as a by-catch species in artisanal fisheries from Brazil to Argentina. The egg masses are described, and several spawning areas are identified. *L. gahi* egg masses were composed of a variable number of capsules (6–345) enclosing 40–150 eggs/embryos. *L. sanpaulensis* egg masses consisted of numerous capsules (6–465) containing approximately 240–320 eggs/embryos. The size range of the eggs was 2.1–2.3 mm for *L. gahi* and 1.2–1.3 mm for *L. sanpaulensis* from Nuevo Gulf, showing good correspondence with size of the mature oocytes carried in the oviducts by the females of each species at the same location. *L. gahi* egg masses were located in San Matías, the San José and Nuevo gulfs, Cape Tres Puntas, and Beagle Channel, usually attached to hard substrates (e.g., kelp) or objects laying on the seafloor (e.g., stones, shells, ropes, or even fishing lines) at depths from 1–15 m. *L. sanpaulensis* egg masses were found in Nuevo Gulf on sandy and muddy bottoms at depths of 5–15 m. Throughout a survey conducted from March 1996 to February 2000 in Nuevo Gulf, in an area within the distribution range of both species, *L. gahi* egg masses were found more frequently; *L. gahi* egg masses were observed every month of the year but February, whereas *L. sanpaulensis* egg masses were detected only from February to May.

KEY WORDS: *Loligo gahi*, *Loligo sanpaulensis*, egg masses, eggs, embryos, spawning grounds, Argentina, Patagonia

INTRODUCTION

Two loliginid squid species inhabit the Atlantic coast of Patagonia: *Loligo gahi* (D'Orbigny, 1835) and *L. sanpaulensis* (Brakoniecki, 1984). *L. gahi* is a species distributed in the southeastern Pacific from Perú to Tierra del Fuego (Cardoso et al. 1998) and in the southwestern Atlantic from Tierra del Fuego to 36°S (Castellanos & Cazzaniga 1979, Vigliano 1985). *L. sanpaulensis* is a species associated with coastal waters, distributed from San Jorge Gulf (Castellanos 1967) to Brazil (20°S) (Roper et al. 1984). Both species are present in the San Matías Gulf (Gonzalez 1999) and in the Nuevo and San Jose gulfs (Ré et al., unpublished manuscript). The fishery of *L. gahi* in the southwestern Atlantic is the second most important loliginid fishery worldwide, reaching average annual captures over 56,000 t during 1988–1997 (FAO 1999). *L. sanpaulensis* constitutes a by-catch species for local fisheries along the Atlantic coast of South America from 23°S (Costa & Fernandes 1993) to 43°S (Castellanos & Cazzaniga 1979).

The spawning areas of loliginid squids have been studied in some commercially valuable species (Vecchione 1988, Augustyn 1990, Baddyr 1991, Porteiro & Martins 1992, Sauer et al. 1992, Sauer et al. 1993). The data on the spawning areas of loliginids in the southwestern Atlantic are scarce (Andriguetto & Haimovici 1996, Ré et al., unpublished manuscript, Arkhipkin et al., 2000). Moreover, the location of these areas has been a matter of speculation until recently (Chesheva 1990, Hatfield et al. 1990, Andriguetto & Haimovici 1996).

The egg masses of Loligo are typical among those of the cephalopods (Arnold & Williams Arnold 1977, Sweeney et al. 1992); however, there are aspects (e.g., the number of capsules per egg mass, the number of eggs per capsule, the egg sizes, and the type of substratum on which the egg masses are attached) that are important to characterize the egg masses to the taxonomic level of species and that have not been reported in *L. sanpaulensis* and have been studied only recently in *L. gahi* (Guerra et al. 2001, Arkhipkin et al. 2000). For both species, the existence of one or more laying periods at different locations is still a subject of debate (Hatfield et al. 1990, Hatfield 1991, Costa & Fernandes 1993, Andriguetto & Haimovici 1996). The aims of the present study were (1) to find and identify the egg masses of *L. gahi* and *L. sanpaulensis*, (2) to locate spawning areas of both species along the Atlantic coast of Patagonia, (3) to study the seasonality of both species' spawning in a given area, and (4) to relate seasonality to the local temperature regime to identify critical values of temperature that could restrict or favor spawning.

MATERIALS AND METHODS

A continuous survey on the egg masses deposited by female loliginid squids in Nuevo Gulf, Argentine Patagonia (Fig. 1), was conducted between March 1996 and June 1998. Four buoyed ropes with weights attached were deployed on the sea bottom at Ameghino Point (March 1996-June 1996) and Kaiser Beach (July 1996-June 1998) (Fig. 1) at depths from 5–15 m (200—1,000 m from the coast). To stimulate *Loligo* females to lay their eggs on the ropes, artificial egg masses made up of small polyethylene bags filled with polystyrene spheres were attached to the ropes' bottom ends. The ropes were monitored every 2–4 wk depending on weather conditions. Seawater temperature, salinity, and pH were registered with a manual electronic sensor (Horiba Inc., Kyoto, Japan) at every control date. From August 1996 to February 2000, eight other spawning sites were found at Nuevo and San José gulfs and Beagle Channel (Fig. 1) by scuba diving and by collection of stranded egg masses on the beach. Additionally, two Loligo spawning sites were identified at Cape Tres Puntas and San Matías Gulf (Fig. 1) from the analysis of egg masses provided by Dr. Alejandro Petovello (Santa Cruz Province Fisheries Department) and Dr. Raúl Gonzalez (Almirante Storni Marine Biology Institute).

The capsules from each egg mass were counted, and the average number of eggs/embryos per capsule was estimated from a 10-capsule sample per egg mass or from the capsules available when less than 10. The embryonic stages present in each egg mass

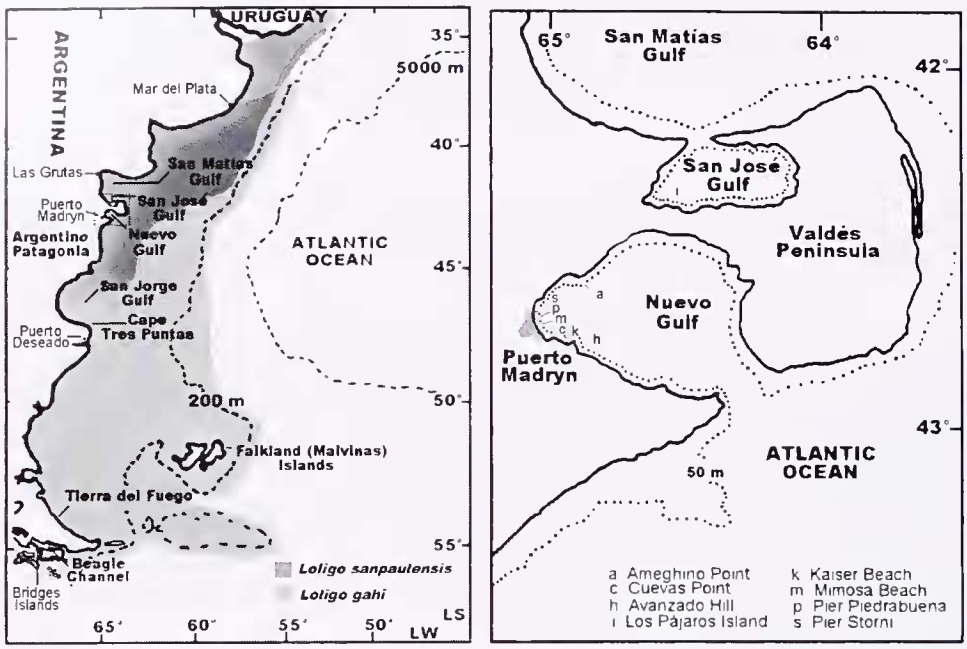

Figure 1. Area of distribution of *Loligo gahi* and *L. sanpaulensis* in Patagonia and location of the spawning areas identified in this study. Data from Vigliano (1985), Inada et al. (1986), and personal observations.

were identified following Arnold's scale (Arnold 1965). A 100-egg sample per egg mass (10 eggs × 10 capsules) was measured in egg masses showing embryonic stages previous or equal to 13 (beginning of the blastoderm expansion; Arnold 1965). On the basis of the egg counts and measurements, the egg masses were classified into different types. To identify these egg mass types to the species level, samples of the mature oocytes were taken from the ovaries and oviducts of 10 *L. gahi* (89–192 mm ML) and 10 *L. sanpaulensis* (67–157 mm ML) mature females captured by coastal seine and jigging at Nuevo Gulf. For each species, the lengths of 200 oocytes (20 oocytes × 10 females) were measured. Additionally, samples of 100 eggs/mature oocytes were randomly taken in triplicate from each of the egg mass types and from the ovaries and oviducts of the *L. gahi* and *L. sanpaulensis* mature females (3 × 10 oocytes × 10 females) from Nuevo Gulf, dried to constant weight, and weighed. All measurements were done at 25× magnification with a Wild dissecting microscope (Wild, Heerbrugg, Switzerland) equipped with an eyepiece; weights were taken to the nearest 0.01 g using a Mettler PC 440 – Delta Range electronic scale (Mettler Instruments, Zürich, Switzerland). The hatching paralarvae from each egg mass type were characterized on the basis of their mantle lengths and chromatophore arrangements.

RESULTS

Two egg mass types with distinctive eggs/embryos sizes and numbers of eggs per capsule were found in Nuevo Gulf. Each egg mass type, and also the capsules, eggs, and embryos themselves, will be hereafter referred to as type 1 and 2. The type 1 Loligo egg masses were regularly found attached to the ropes at the two locations of the same gulf where they were deployed: Ameghino Point and Kaiser Beach (Fig. 1; Table 1). They were also located by scuba diving on gravel substrate or on objects such as shells, ropes, or fishing lines at different locations of the same gulf: Pier Piedrabuena (Puerto Madryn), Cuevas Point, Avanzado Hill, and by collection of stranded material on Mimosa Beach (Fig. 1; Table 1). Type 1 egg masses were also found throughout a wide latitudinal range along the Atlantic coast of Patagonia: Las Grutas (San Matías Gulf), Los Pájaros Island (San José Gulf), Puerto Deseado (Cape Tres Puntas), and Bridges Islands (Beagle Channel). Type 2 egg masses were found only by scuba diving, anchored in sandy or muddy bottoms of Nuevo Gulf, near the pillars of Pier Almirante Storni (Puerto Madryn), and in the vicinity of Las Piedras Park, a recreational diving spot located a few hundred meters from the Puerto Madryn's waterfront (Fig. 1; Table 1).

Type 1 and 2 egg masses are well-defined structures and are made up of several capsules attached to each other and to the substrata at their basal ends by short stalks. Each capsule consists of an inner core of jelly surrounded by a spiral band of jelly that contains a row of eggs and an external covering formed by several layers of translucent material that provides cohesion and protection to the eggs (Fig. 2). The bases of the stalks, composed of the same material as the capsule's core and deprived of any external layer, are entangled, forming a bundle that is attached to the substrate. The number of capsules per egg mass varied from less than 10 to more than 300 for the type 1 egg masses and from less than 10 to more than 400 for the type 2 egg masses (Table 1). Some of the egg masses found during the survey consisted of groups of capsules, each one containing embryos in a particular stage of development (multiple egg masses; Table 1). This can be attributed to the deposition of egg capsules in a common egg mass by more than one female at various time intervals. The average number of eggs/embryos per capsule was 69 (n = 340) for the type 1 and 298 (n = 50) for the type 2 egg masses, but these numbers varied considerably between egg masses of the same type (Table 1).

Both type 1 and 2 eggs were approximately oval in shape, with the animal pole more pointed than the vegetal pole. The average size of the eggs was 2.2 mm (2.1–2.3 mm; n = 500) for type 1 egg masses and 1.2 mm (1.2–1.3 mm; n = 200) for type 2 egg masses (Fig. 2). The dry weights of 100 eggs were 0.10 g for each of the three replicates of type 1 eggs and 0.03 g for each of the three replicates of type 2 eggs.

TABLE 1.

Results of the survey on Loligo spp. egg masses in the Atlantic coast of Patagonia.

Record	Location	Date of collection	Depth (m)	pH	Temperature (°C)	Salinity (ppt)	Capsules per egg mass	Average eggs per capsule	Stage of embryonic development	Type
1*	Las Grutas	5/11/84	5	n/a	n/a	n/a	15	52	13–22	1
2	Puerto Deseado	12/15/95	Stranded	n/a	n/a	n/a	n/a	55	28	1
3	Ameghino Point	3/12/96	10	8.1	16.3	34.6	65	46	28	1
4	Ameghino Point	3/12/96	5	8.1	16.3	34.6	6	52	16	1
5	Ameghino Point	3/28/96	10	8.08	16.3	34.6	20	80	28	1
6	Ameghino Point	4/26/96	10	8.18	14.5	35.0	10	63	29	1
7	Los Pájaros Island	5/5/96	Stranded	n/a	15	n/a	153	92	17	1
8	Ameghino Point	5/29/96	15	8.2	12.9	35.0	35	65	29	1
9*	Ameghino Point	5/29/96	10	8.2	12.9	35.0	37	94	18–23	1
10	Ameghino Point	5/29/96	10	8.2	12.9	35.0	22	63	12	1
11	Kaiser Beach	7/26/96	15	8.21	10.6	35.1	78	61	10	1
12	Pier Piedrabuena	8/13/96	5	8.22	10.2	35.1	38	53	15	1
13*	Kaiser Beach	8/29/96	15	8.26	10.6	35.2	52	58	15–17	1
14	Kaiser Beach	9/12/96	10	8.3	11	34.8	49	81	14	1
15	Kaiser Beach	9/12/96	5	8.31	10.8	35.1	123	69	13	1
16	Kaiser Beach	9/12/96	10	8.3	11	34.8	23	63	13	1
17*	Kaiser Beach	9/30/96	10	8.29	11.8	35.1	345	63	12-21-30	1
18	Kaiser Beach	10/14/96	10	8.3	13.2	34.6	85	85	19	1
19*	Kaiser Beach	10/14/96	10	8.3	13.2	34.6	98	42	13–18	1
20*	Kaiser Beach	11/27/96	5	8.4	15.4	34.7	69	44	28–29	1
21	Kaiser Beach	11/27/96	5	8.4	15.4	34.7	30	76	10	1
22	Kaiser Beach	12/26/96	5	8.35	14.9	34.6	13	39	0	1
23	Kaiser Beach	1/28/97	10	8.46	18	34.8	85	73	28	1
24	Kaiser Beach	1/29/97	10	8.46	18	34.8	63	82	13	1
25	Kaiser Beach	3/4/97	10	8.44	19.3	34.2	7	91	8	1
26	Kaiser Beach	3/25/97	5	8.49	16.5	34.8	3	63	29	1
27	Cuevas Point	6/23/97	5	8.58	12.8	35.0	58	74	26	1
28	Cuevas Point	6/23/97	5	8.58	12.8	35.0	60	82	19	1
29	Cuevas Point	6/23/97	5	8.58	12.8	35.0	24	88	10	1
30	Mimosa Beach	7/3/97	Stranded	n/a	n/a	n/a	62	55	29	1
31	Kaiser Beach	9/10/97	10	n/a	n/a	n/a	243	48	n/a	1
32	Bridges Islands	6/15/97	12	n/a	n/a	n/a	51	74	12	1
33*	Pier Storni	3/17/98	15	8.5	16.8	34.2	180	309	Various	2
34*	Pier Storni	3/17/98	15	8.5	16.8	34.2	465	322	Various	2
35	Pier Storni	3/26/98	15	8.4	16.5	34.0	13	243	13	2
36*	Pier Storni	3/26/98	15	8.4	16.5	34.0	82	314	Various	2
37	Avanzado Hill	3/31/98	1	n/a	n/a	n/a	28	154	11	1
38	Pier Storni	4/4/98	15	8.22	16.3	34.0	88	n/a	14-22-26	2
39	Pier Storni	4/4/98	15	8.2	16.3	34.0	52	n/a	29	2
40	Pier Storni	5/22/98	15	8.07	14.8	34.0	6	n/a	>29	2
41	Kaiser Beach	6/30/98	10	8.25	11.2	34.3	138	60	12	1
42*	Bridges Islands	8/17/98	6	n/a	5	n/a	35	63	Various	1
43	Las Piedras Park	2/4/00	5	n/a	17.4	n/a	20	302	21	2

No egg masses were found on the ropes on 8/13/96, 1/18/97, 2/17/97, and 4/23/97. Embryonic stages follows the scale of Arnold (1965).
n/a: not available.
*Multiple egg mass (groups of capsules with embryos at different stages of development).

Besides larger absolute sizes, type 1 embryos show external yolk sacs proportionally larger than those of type 2 embryos at the same stages of development (Fig. 3). Therefore, throughout their development, type 1 embryos show features closer to those described by Naef (1928) for the embryos of *L. vulgaris* (Lamark, 1798), and type 2 embryos show characteristics that resemble those illustrated by Arnold (1965) for the embryos of *L. pealei* (Le Sueur, 1821). At hatching, type 1 embryos attain mantle lengths of 2.6–3.2 mm, and type 2 embryos attain mantle lengths of 1.4–1.7 mm (Fig. 3). The most common chromatophore arrangements found on the embryos of both types of paralarvae are shown in Figure 4. Chromatophores were red or yellow on the ventral surface of both types of paralarvae, brown or yellow on the dorsal surface of type 1 paralarvae, and only yellow on the dorsal surface of the type 2 paralarvae. Orange chromatophores were observed only on the embryos in stages 26–28 of Arnold's scale (Arnold 1965). The cheek patches of the type 1 hatchlings consisted in four red chromatophores, but three chromatophores on either one or both cheeks were frequently observed. The type 2 hatching paralarvae displayed only two red chromatophores on each cheek patch.

The average size of the mature oocytes sampled from the ovaries and oviducts of 10 *L. gahi* females was 2.2 mm (2.0–2.4 mm; $n = 200$); the average size of the oocytes sampled from 10 female

Figure 2. Aspect of *Loligo spp.* egg mass types found in the Atlantic coast of Patagonia. Left: type 1 egg capsule from Beagle Channel, Center: type 1 *Loligo sp.* egg capsule from Nuevo Gulf, Right: type 2 egg capsule from Nuevo Gulf (scale bar = 6 mm).

L. sanpaulensis was 1.2 (1.2–1.3 mm; $n = 200$). The dry weights of 100 oocytes were 0.10 g for each of the three replicates of *L. gahi*'s oocytes and 0.03 g for those of *L. sanpaulensis*. Given that *L. gahi* and *L. sanpaulensis* are the only loliginids that inhabit the waters of northeastern Patagonia (Castellanos & Cazzaniga 1979, Inada et al. 1986), the striking correspondence between the sizes and weights of each egg type and the mature oocytes of either species make it possible to state that the type 1 egg masses belong to *L. gahi* and type 2 egg masses belong to *L. sanpaulensis*.

From the egg masses obtained in Bridges Islands (Fig. 1; Table 1), those found in August 1998 showed eggs identical in size to the *L. gahi* eggs from Nuevo Gulf (average 2.2 mm, range 2.1–2.3 mm; $n = 200$). The egg mass found in the same locality in June 1997 (Table 1) showed eggs somehow bigger than those normally found in the type 1 egg masses (average 2.6 mm, range 2.3–3.0 mm; $n = 200$). Moreover, this was composed of two different groups of capsules showing eggs that were 2.3–2.6 mm and 2.6–3.0 mm. However, the number of eggs per capsule fell into the range reported for the type 1 egg masses (Table 1). The dry weight of each of the three 100-egg replicates taken from this egg mass was 0.20 g.

In Nuevo Gulf, *L. gahi* spawned almost continually throughout the year; February was the only month in which egg masses were not found (Table 1). According to historical registers (more than 10 years, hourly records) taken at Nuevo Gulf (unpublished data, Puerto Madryn's Tides Control Station, Hydrographic Service, Argentine Navy), the monthly average of daily minimum SST reaches a minimum in August (7.3°C), and the monthly average of daily maximum SST reaches a maximum in February (23°C). SST registered in Beagle Channel at the time of collection of type 1 egg masses (August 1998) was 5°C. These data show that *L. gahi* can spawn at temperatures as low as 5°C and that spawning could be limited at temperatures close to 23°C. Although the sampling procedure limits the quantitative estimation on spawning peaks of *L. gahi* in Nuevo Gulf, it is interesting that *L. gahi* egg masses with higher numbers of capsules were registered in September in both 1996 and 1997 (Table 1). Type 2 egg masses were found in Nuevo Gulf from March 1998 to May 1998 and in February 2000 (Table 1). The analysis of the embryonic stages found in these egg masses

Figure 3. Compared aspect of the type 1 and type 2 *Loligo* fixed embryos. Upper left: type 2 embryo at stage 30; upper rigth: type 2 embryo at stage 21; lower left: type 1 embryo at stage 30; lower rigth: type 1 embryo at stage 21 (scale bar = 1 mm). ys: yolk sac. Embryonic stages following the scale of embryonic development of Arnold (1965).

suggests that the egg masses were actually deposited from March 1998 to April 1998 and in January 2000. These results show that the spawning season of *L. sanpaulensis* in the study area extends from summer to early fall. During this period, the monthly average of daily minimum SST reaches a minimum in April (12°C), and the monthly average of daily mean SST ranges between 15°C (April) and 17.5°C (February).

DISCUSSION

It has been observed that some loliginids deposit their egg masses on the ropes and PVC pipes used as traps for octopuses (Porteiro & Martins 1992, Ré et al. 1996). Also, artificial egg masses such as those used in this work have been reported to cause a visual stimulus for loliginids to mate and spawn (Arnold & Williams Arnold 1977, Yang et al. 1986, Vecchione 1988). The devices deployed in this study to examine the laying activities of the Loligo species present in Nuevo Gulf are a simplification of those traps. These structures stimulated the spawning of *L. gahi* but did not show any results with *L. sanpaulensis*. This seems reasonable, considering that *L. gahi* deposits its egg masses on hard substrata and *L. sanpaulensis* spawns on soft bottoms. A distinct selection of substrata for egg laying has also been observed in two sympatric loliginids in the Gulf of Mexico, *L. pealei* selecting hard substrates and *L. plei* (Blainville, 1823) preferring soft

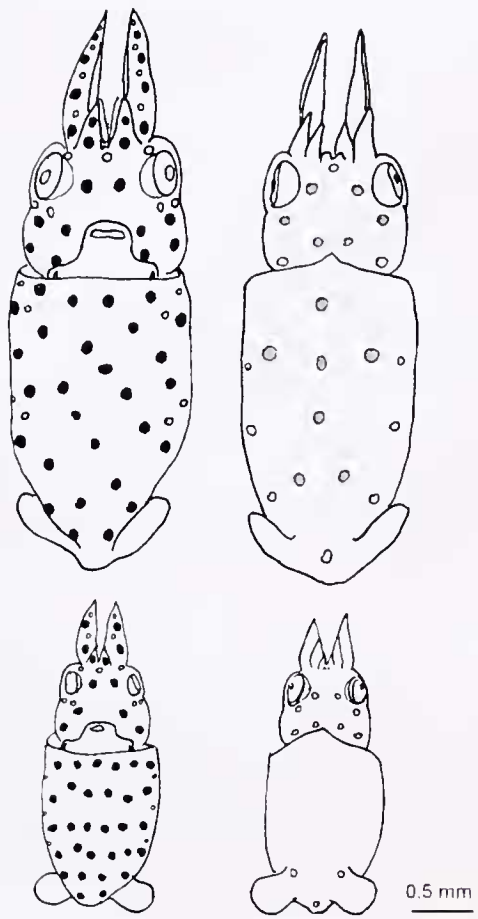

Figure 4. Chromatophore arrangements on the ventral (left) and dorsal (rigth) surfaces of the *Loligo spp.* hatching paralarvae from coastal waters of Patagonia. Top: type 1 paralarva, bottom: type 2 paralarva. Black circles represent red chromatophores, gray circles represent brown chromatophores and empty circles represent yellow chromatophores.

substrates (Vecchione 1988). Arkhipkin et al. (2000) found egg masses of *L. gahi* attached to no other substrate than kelp and concluded that the spawning sites of the species could be limited to shallow waters. In the present work, egg masses of *L. gahi* have been found attached not only to kelp but also to other types of hard substrate.

The structure of both species' egg masses, several capsules enclosing a row of eggs arranged in a coiled pattern along their longitudinal axle, is typical of Loligo species (Arnold & Williams Arnold 1977). The number of capsules per egg mass is variable for *L. gahi* and *L. sanpaulensis* egg masses; this variability is probably related to the size and physiological condition of the mother. This has also been observed in *L. vulgaris* reynaudii (Lamark, 1798) by Sauer et al. (1993), who found concentrations of egg masses more than 3 m in diameter surrounded by smaller ones (1–10 capsules per egg mass), and by Vecchione (1988), who observed Loligo sp. egg masses in the Gulf of Mexico that were made up of 10–40 capsules. However, as it has been observed in the present study, the variability could in part be the result of the deposition of multiple egg masses on a common mass by more than one female. Also, it should be noted that even when most egg masses were considered as individual egg masses, it is possible that these were deposited by more than one female within a brief period of time, so they could not be distinguished from each other on the basis of embryo maturity. This has also been suggested by Arkhipkin et al. (2000) who found 6–141 capsules per egg mass in *L. gahi*.

The number of eggs per capsule in the egg masses of *L. gahi* is comparable to that reported for other loliginids, such as *L. duvaucelii* (D'Orbigny, 1848) (125–150 eggs per capsule; Asokan & Kakati 1991), *L. forbesi* (Steenstrup, 1856) (39–52 eggs per capsule; Porteiro & Martins 1992), and *L. vulgaris reynaudii* (148 ± 37 [mean ± SD] eggs per capsule; Sauer et al. 1993). The number of eggs per capsule reported in this study is comparable to that found by Guerra et al. (2001) (50–60 eggs per capsule) from a 12-capsule egg mass of *L. gahi* found in Reñaca, Chile (32°58'S, 71°32'W). Also, the mean number of eggs per capsule observed in the present work (69 eggs per capsule) is similar to that reported by Arkhipkin et al. (2000) for the same species (71 eggs per capsule). The number of eggs per capsule of *L. sanpaulensis* is comparable to that for *L. plei* (200–300 eggs per capsule) reported by Waller and Wicklung (1968).

The egg-size range of *L. opalescens* (Berry, 1911) (2.0–2.5 mm; Fields 1965) shows the greatest resemblance to that of *L. gahi*. Other species with close egg-size ranges are *L. vulgaris* (2.3–2.7 mm) (Worms 1983, cited in Baeg et al. 1992) and *L. bleekeri* (Keferstein, 1866) (2.6–2.7 mm; Baeg et al. 1992). The size range observed in the eggs of *L. gahi* from Nuevo Gulf and the egg mass found in Bridges Islands in August 1998 (2.1–2.3 mm) is within the range reported by Arkhipkin et al. (2000) (2.0–2.5 mm) from egg masses found in the Falkland (Malvinas) Islands, and the size range from the eggs found in Bridges Islands in June 1997 (2.3–3.0 mm) is comparable to that reported by Guerra et al. (2001) from the eggs found in Reñaca, Chile (2.6–3.1 mm). On the other hand, the size range of the *L. sanpaulensis* eggs falls within the range reported for the Northeastern Atlantic species *L. pealei* (1.1–1.6 mm; Summers 1983, cited in Baeg et al. 1992).

The chromatophore arrangements displayed by the hatching paralarvae of *L. gahi* and *L. sanpaulensis* were easily distinguishable from each other. The pattern found in *L. gahi* closely resembles that reported by McConathy et al. (1980) for *L. opalescens*, and the pattern found in *L. sanpaulensis* is similar to that observed by the same authors in *Lolliguncula brevis* (Blainville, 1823). The pattern of chromatophore arrangements reported by Arkhipkin et al. (2000) for the paralarvae of *L. gahi* is similar to that found in this study. However, this authors omitted two yellow chromatophores placed on the ventral surface of the head, anterior to the eyes, that were regularly observed in the *L. gahi* hatchlings from this study, both from Nuevo Gulf and Bridges Islands, and in other loliginids (Naef 1928, McConathy et al. 1980, Baeg et al. 1992, Blackburn et al. 1998). Also, Arkhipkin et al. (2000) incorrectly report the presence of brown chromatophores on the ventral surface of the hatching paralarvae, which are actually red, and the presence of orange chromatophores, which are actually yellow (orange chromatophores are present only in earlier stages of the embryonic development).

L. gahi shows a year-round spawning season in Nuevo Gulf, which could be limited at the depth range covered in this study (0–15 m) by the maximum SST of the hottest month. Continuous spawning throughout the year has also been reported for *L. vulgaris* reynaudii (Sauer et al. 1992) from South Africa and *L. forbesi* (Lum Kong et al. 1992) from Irish waters. The observation of two peaks of recruitment of *L. gahi* to the Falkland (Malvinas) Islands fishery has led some authors to consider two major spawning peaks for that area (Patterson 1988, Hatfield et al. 1990).

Recently, a third recruitment peak has been identified (Agnew et al. 1998, Hatfield & Murray 1999). The hypothesis of a spawning peak in September for *L. gahi* in Nuevo Gulf, on the basis of this study's preliminary observations on the size of the egg masses, agrees with the observations of Portela et al. (1994), who reported maximum proportions of spawning *L. gahi* individuals in September between 42°S and 49°S during a survey conducted from March to October 1989.

On the basis of the results of the egg mass survey in Nuevo Gulf, it can be stated that the spawning activity of *L. sanpaulensis* near the southern limit of its geographic distribution is restricted to summer. Unpublished data on the reproductive cycle of *L. sanpaulensis* in Northern Patagonia on the size and maturity structure of the adult and juvenile population (Barón & Ré, Pers. Comm.) is consistent with this conclusion. Previous studies on the reproductive cycle of *L. sanpaulensis* in fishing areas of central Argentina (Mar del Plata, 38°S) and Brazil (Cabo Frio, 21°S) indicated two spawning peaks per year (Vigliano 1985, Costa & Fernandes 1993). However, an extended spawning period for *L. sanpaulensis* throughout the year has been considered for southern Brazil in a more recent study (Andriguetto & Haimovici 1996). In Nuevo Gulf, spawning seems to be limited by water temperature below 12°C and facilitated by a monthly average of daily mean temperature in the range of 15–17.5°C. This temperature range is in agreement with the observations of Andriguetto and Haimovici (1996) who reported the finding of undetermined Loligo egg masses, presumably of *L. sanpaulensis*, in Southern Brazil at bottom temperatures of 17.5°C–17.8°C.

The differences in the sizes and weights of the eggs in the egg mass found in Bridges Islands in July 1997 cannot be fully explained on the basis of the present information. The existence of two groups of capsules enclosing eggs with different size ranges but the same stage of development suggests that this was actually a multiple egg mass deposited by two females within a brief time interval. Given that the number of eggs per capsule of this egg mass is within the range observed for type I egg masses, this could be a *L. gahi* egg mass adapted to the low temperature conditions of the Beagle Channel. On the other hand, it could be thought of as the egg mass of another Loligo species. Filippova (1969, cited in Castellanos & Cazzaniga 1979) postulated the existence of two different taxonomic entities within *L. gahi* (*L. gahi* in waters of the Pacific and *L. patagonica* in the Atlantic). However, Castellanos and Cazzaniga (1979) and Brakoniecki (1984) presented evidence that *L. patagonica* is a junior synonym of *L. gahi*.

The present work shows the wide ranges of latitude and temperature suitable for the spawning activity of *L. gahi* along the Patagonian Coast and the narrow range of temperature at which *L. sanpaulensis* can reproduce near the southern limit of its distribution. Further studies on the spawning grounds of *L. gahi* and *L. sanpaulensis* must emphasize quantitative estimations to provide predictive data on the recruitment patterns of both species.

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